

CLAIMS:

1. A method for the production of a polypropylene comprising branches in the polymer backbone, which method comprises:

(a) forming macromers from an olefin monomer; and

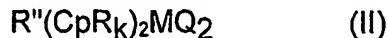
(b) polymerising propylene in the presence of the macromers and a catalyst, under polymerising conditions which favour the incorporation of the macromers into the polypropylene backbone, to form a branched polypropylene;

wherein the catalyst employed in step (a) comprises a metallocene catalyst which promotes a chain terminating β -alkyl elimination reaction to form terminal unsaturated groups in the macromers and is selected from



wherein both Ind are the same and an indenyl group or a tetrahydroindenyl group; each R is the same or different and is a hydrocarbyl group having from 1-20 carbon atoms; m is an integer from 0-6; R'' is a structural bridge imparting stereorigidity to the catalyst and containing at most one carbon atom; M is a metal atom from group IVB or is vanadium; and each Q is a hydrocarbon having from 1-20 carbon atoms or is a halogen;

or from



wherein Cp is a cyclopentadienyl ring; R'' is a structural bridge imparting stereorigidity to the catalyst and containing at most one carbon atom; each R is the same or different and is a hydrocarbyl group having from 1-20 carbon atoms, k is an integer of from 1-4; M is a metal atom from group IVB or is vanadium; and each Q is a hydrocarbon having from 1-20 carbon atoms or is a halogen.

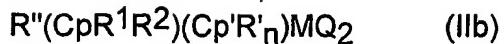
2. The method according to claim 1, wherein the bisindenyl catalyst (I) employed in step (a) comprises a symmetrical substitution pattern and both indenyl or tetrahydroindenyl groups are mono-substituted in position 3.
3. The method according to claim 2, wherein the substituent on each indenyl or tetrahydroindenyl group is a bulky substituent.
4. The method according to claim 1, wherein the di-cyclopentadienyl catalyst (II) employed in step (a) comprises a symmetrical substitution pattern and both cyclopentadienyl groups are mono-substituted in position 3.
5. The method according to claim 4, wherein the substituent on each cyclopentadienyl group is a bulky substituent.
6. The method according to any one of claims 2 to 5, wherein the bulky substituent is selected from an isopropyl group, a tertiary butyl group and a trimethylsilyl (TMS) group.
7. The method according to any preceding claim, wherein the catalyst employed in step (b) comprises a metallocene catalyst selected from any of formulae (I)-(V):



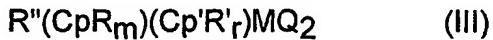
wherein each Ind is the same or different and is an indenyl group or a tetrahydroindenyl group; each R is the same or different and is a hydrocarbyl group having from 1-20 carbon atoms; m is an integer from 0-6; R" is a structural bridge imparting stereorrigidity to the catalyst; M is a metal atom from group IVB

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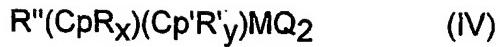
or is vanadium; and each Q is a hydrocarbon having from 1-20 carbon atoms or is a halogen;



wherein Cp is a cyclopentadienyl ring; Cp' is a fluorenyl ring; R'' is a structural bridge imparting stereorigidity to the catalyst; R¹ is a substituent on the cyclopentadienyl ring which is distal to the bridge, which distal substituent comprises a bulky group of the formula XR*₃ in which X is an atom from group IVA and each R* is the same or different and is chosen from a hydrogen or a hydrocarbyl group having from 1-20 carbon atoms; R² is a substituent on the cyclopentadienyl ring which is proximal to the bridge and positioned non-vicinal to the distal substituent and is of the formula YR#₃ in which Y is an atom from group IVA, and each R# is the same or different and is chosen from a hydrogen or a hydrocarbyl group having from 1-7 carbon atoms; the Cp ring may optionally comprise further substituents in addition to R¹ and R²; each R' is the same or different and is a hydrocarbyl group having from 1-20 carbon atoms, and n is an integer of from 0-8; M is a metal atom from group IVB or is vanadium; and each Q is a hydrocarbon having from 1-20 carbon atoms or is a halogen;



wherein Cp is a substituted or unsubstituted cyclopentadienyl ring; Cp' is a substituted or unsubstituted fluorenyl ring; R'' is a structural bridge imparting stereorigidity to the component; each R is the same or different and is a hydrocarbyl group having from 1-20 carbon atoms; each R' is the same or different and is a hydrocarbyl group having from 1-20 carbon atoms; m is an integer of from 0-4; r is an integer from 0-8; M is a metal atom from group IVB or is vanadium; and each Q is a hydrocarbon having from 1-20 carbon atoms or is a halogen;



wherein Cp is a substituted cyclopentadienyl ring; Cp' is a substituted or unsubstituted fluorenyl ring; R'' is a structural bridge imparting stereorrigidity to the component; each R is the same or different and is a hydrocarbyl group having from 1-20 carbon atoms, each R' is the same or different and is a hydrocarbyl group having from 1-20 carbon atoms, and x and y are independently an integer of from 0-4 and 0-8 respectively; M is a metal atom from group IVB or is vanadium; and each Q is a hydrocarbon having from 1-20 carbon atoms or is a halogen; wherein the CpR_X group lacks bilateral symmetry; and wherein the Cp group is preferably substituted at the 3-position;



wherein Cp is a substituted cyclopentadienyl ring or a substituted or unsubstituted fluorenyl ring; R'' is a structural bridge between Cp and X imparting stereorrigidity to the component; each R is the same or different and is selected from a hydrocarbyl group having from 1-20 carbon atoms, a halogen, an alkoxy group, an alkoxyalkyl group, an alkylamino group or an alkylsilylo group; when Cp is a cyclopentadienyl ring; q is an integer from 0-4; and when Cp is a fluorenyl ring q is an integer from 0-8; X is a heteroatom from group VA or group VIA, substituted or unsubstituted; M is a metal atom from group IIIB, IVB, VB or VIB in any of its theoretical oxidation states; and each Q is a hydrocarbon having from 1-20 carbon atoms or is a halogen; wherein the bilateral symmetry of the CpR_q group is maintained; and wherein the CpR_q group is preferably symmetrically substituted.

8. The Method according to any of claims 1 to 7, wherein M is Ti, Zr, or Hf.
9. The method according to any of claims 1 to 8, wherein Q is Cl.

10. The method according to any of claims 1 to 9, wherein R" is a (Me₂C), H₂C, or a Ph₂C group.
11. The method according to any preceding claim, wherein in step (a) the macromers are formed in the presence of ethylene to promote the formation of terminal ethylenyl groups in the macromers.
12. The method according to any preceding claim, wherein the olefin monomer for forming the macromers comprises propylene.
13. The method according to claim 12, wherein the steps (a) and (b) are carried out in the same reaction zone and wherein the two catalysts are supported on the same support or on different supports.
14. The method according to claim 12 or claim 13, wherein the macromer forming step (a) is carried out under macromer-forming conditions and the polymerisation step (b) is carried out under polymerisation conditions.
15. The method according to any of claims 1-11, wherein the olefin monomer for forming the macromers comprises an olefin other than propylene.
16. The method according to claim 15, wherein the olefin monomer for forming the macromers comprises ethylene, butene, pentene and/or hexene.

17. The method according to claim 15 or claim 16, wherein the steps (a) and (b) are carried out in separate reaction zones.
18. The method according to any preceding claim, wherein the macromers comprise an olefin monomer, an olefin oligomer or a polyolefin.
19. The method according to claim 18, wherein step (a) is carried out in a first reaction zone and step (b) is carried out in a second reaction zone in series with the first reaction zone.
20. The method according to any preceding claim, wherein step (b) is carried out at a temperature of 100°C or more.
21. The method according to any preceding claim, wherein step (b) is carried out in the absence of hydrogen.
22. A branched polypropylene obtainable according to a method as defined in any preceding claim.
23. The branched polypropylene according to claim 22, which comprises a branched isotactic polypropylene.
24. A polypropylene foam, prepared from a branched polypropylene as defined in claim 22 or claim 23.
25. A blown film prepared from a branched polypropylene as defined in claim 22 or claim 23.